Original contribution

Capnography enhances surveillance of respiratory events during procedural sedation: a meta-analysis

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Abstract

Study Objective: To determine if capnography, in addition to standard monitoring, identified more respiratory complications than standard monitoring alone.

Design: Meta-analysis.

Setting: University medical center.

Measurements: The electronic databases PubMed, CINAHL, and Cochrane Library (Cochrane Reviews, CENTRAL) were searched for studies published between 1995-2009 reporting adverse respiratory events during procedural sedation and analgesia (PSA) with clearly defined end-tidal carbon dioxide threshold, adult population, clear study design, P-value calculation, similar outcome and predictor variable definitions, and binary independent and dependent variable raw data. Five such studies were evaluated independently. A meta-analysis of these studies was performed.

Main Results: During PSA, cases of respiratory depression were 17.6 times more likely to be detected if monitored by capnography than cases not monitored by capnography (95% CI, 2.5-122.1; P < 0.004).

Conclusion: End-tidal carbon dioxide monitoring is an important addition in detecting respiratory depression during PSA.

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1. Introduction

The use of procedural sedation and analgesia (PSA) and patient-controlled analgesia (PCA) has increased in frequency and scope [1]. More clinicians without anesthesia training are performing and monitoring these activities. Although end-tidal carbon dioxide (ETCO₂) monitoring is routinely used during general anesthesia to monitor ventilatory status, this is not the case for PSA and PCA [2], where pulse oximetry and visual inspection represent the standard of care [3]. Pulse oximetry does not provide early detection of hypoventilation, apnea, or airway obstruction [4]. Vargo et al reported a study of 49 patients receiving sedation during upper gastrointestinal (GI) endoscopy in which 54 episodes of apnea were detected

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Disclosure: Drs. Epps and Waugh have consulted for Oridian Capnography, Inc., Needham, MA, USA, a manufacturer of capnography devices.

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in 28 patients by capnography whereas pulse oximetry detected only 27 episodes (50%); none of these events was detected by visual assessment [4]. Some reports question the reported incidence rates of respiratory depression/complications associated with PSA (reported incidence of complications varied between institutions by a factor of 15) and PCA [5,6], suggesting higher rates than the averages typically reported in the literature.

The Joint Commission on Accreditation of Healthcare Organizations (now the Joint Commission) revised the standards for monitoring patient sedation in 2001 [7]. Specific reference to moderate and deep sedation was included in the care and treatment standards. The standards state that qualified personnel should monitor patients receiving sedation during the procedure and recovery phase, and require that heart rate and oxygenation be monitored continuously by pulse oximetry. Adequacy of ventilation and respiratory frequency must be monitored continuously, and the clinician must be prepared to manage a level of sedation that is deeper than intended.

The aim of this analysis was to determine if capnography added to standard monitoring, including pulse oximetry, allowed for identification of significantly more respiratory complications during procedural sedation in adults compared with standard monitoring without capnography.

2. Materials and methods

2.1. Data sources and searches

This meta-analysis followed the PRISMA (“Preferred reporting items for systematic reviews and meta-analyses”) guidelines for reporting analyses [8]. The following databases were searched from 1995-2009 for relevant studies: PubMed (free-access database of the National Library of Medicine, Bethesda, MD, USA); CINAHL (Cumulative Index to Nursing and Allied Health Literature, Ebsco Publishing Co., Glendale, CA, USA); and the Cochrane Library (John Wiley & Sons, Ltd., Hoboken, NJ, USA), specifically Cochrane Reviews and CENTRAL (Cochrane Central Register of Controlled Trials). The search strategies combined keywords, synonyms, and subject headings for the concept “capnography” with keywords, synonyms, and index terms for each of the following two concepts: (PSA or PCA or deep sedation) or (ambulatory surgical procedures or biopsies or refractive surgical procedures or tracheostomy or tracheotomy or paracentesis or surgical procedures, minimally invasive or endoscopic or electroconvulsive therapy or electric countershock or debridement or ablation techniques or induced abortions).

The searches were limited to English language and humans. Titles and abstracts of all study types were scanned for relevancy and special attention was given articles in the subsets of each search identified as trials. The reference lists of studies selected for inclusion were scanned for additional relevant studies. Citations searches for the 16 articles selected for evaluation in the meta-analysis were carried out using both Science Citation Index (Thomson Reuters, New York, NY, USA) and Google Scholar. All searches were performed in July 2009. The detailed search strategy is available in Appendix 1.

2.2. Study selection

Studies had to have a specified abnormal ETCO2 threshold in their definition of an adverse respiratory event to be included in the analysis. Single case reports were excluded from our analysis. “Capnography” was added as a medical subject heading (MeSH) search term in 1997, so synonymous search terms were included to capture pre-1997 publications (Appendix 1). The 16 articles identified by the search strategy were evaluated by two authors to determine if the inclusion criteria were met. In addition to the previously described clinical selection criteria, the following parameters were considered when including studies into the meta-analysis: adult populations, clear description of the study design, P-value calculation, similar outcome and predictor variable definitions, and binary independent and dependent variable raw data. The 5 articles found to meet these additional criteria were again evaluated independently by a third author (statistician) to confirm inclusion criteria (Fig. 1).

2.3. Data extraction and quality assessment

Respiratory complications during PSA was the broad outcome measure as indicated by one of the following: respiratory depression, apnea, oxygen desaturation, airway obstruction, or the need for oxygen supplementation. The predictor variable was defined as ETCO2 greater than 50 mmHg or ETCO2 increase greater than 10 mmHg from the baseline. Data from the 5 studies were abstracted in the format of a two-by-two table (Tables 1 and 2). Cases were defined as the number of patients experiencing respiratory depression during the procedure in the study sample. Patients who experienced multiple episodes of respiratory depression were considered only as one case. Diagnostic odds ratios (ORs) for each study were calculated using the standard formula: OR = ad/bc, where a = true positives, d = true negatives, b = false positives, and c = false negatives (Table 1).

2.4. Data synthesis and analysis

Abstracted raw data from the two-by-two tables from each of the studies were aggregated into one dataset (Table 3). SPSS version 15 macros for fixed-effects (Peto & Mantel-Haenszel methods) and random-effects (Dersimonian-Laird method) models were used to estimate pooled crude and weighted overall ORs (SPSS, Inc., Chicago, IL, USA). The
weight of each study was calculated (Table 2) by using the formula: \( w_i = 1/(SE_{log})^2 \). Obtained ORs from each study were logarithmically transformed to assess the distribution within the sample of the 5 selected studies. To determine the significance of the weighted overall ORs and effect sizes, the chi-square test was performed in each model employed (Table 3). Heterogeneity between the studies was assessed in the fixed-effects and random-effects models. Since heterogeneity was high, the random-effects model was performed in addition to the fixed-effects model to allow for variability between the studies. 

Fixed-effects analysis models the systematic between-study differences and assumes subject-level sampling error of the studies included in meta-analytical research. A random-effects model, on the other hand, conceptualizes the current set of studies under consideration to be a random sample picked from a larger population of studies. There are two sources of variability in random-effects model meta-analysis: one

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Fig. 1  Flow diagram of screened, excluded, and analyzed studies.

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**Table 1  Method for data abstraction**

<table>
<thead>
<tr>
<th>Respiratory depression</th>
<th>ETCO₂ elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yes (Exposure)</strong></td>
<td><strong>No (Non-exposure)</strong></td>
</tr>
<tr>
<td><strong>ETCO₂ elevation</strong></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>True positive</td>
<td>False negative</td>
</tr>
<tr>
<td>Respiratory events detected by capnography</td>
<td>Respiratory events not detected by capnography</td>
</tr>
<tr>
<td>B</td>
<td>D</td>
</tr>
<tr>
<td>False positive</td>
<td>True negative</td>
</tr>
<tr>
<td>No respiratory event, though one was detected by capnography</td>
<td>No respiratory event and no detection by capnography</td>
</tr>
</tbody>
</table>

ETCO₂ = end-tidal carbon dioxide.
due to the variability of the effect parameters, and the other, due to the sampling variability of experimental units (ie, subjects) into studies. In case of high heterogeneity of individual parameter estimates of each study, random-effects analysis takes into account the 'true variance' (or the remaining unmeasured random effects between studies) in addition to the modeled between-study differences and the sampling error assumed in fixed-effects models. It should be noted that the random-effects model usually gives less precise estimates and wider confidence intervals (CIs). The Cochran Q heterogeneity test was performed to assess heterogeneity before estimating tau-square. Then tau-square and i-square statistics were estimated. All analyses were conducted at the 95% confidence level. P-values less than 0.05 were considered to indicate a statistically significant result.

3. Results

3.1. Brief descriptions of the 5 selected studies

Miner et al (2002) [1]: This prospective study of 74 adults receiving procedural sedation sought to evaluate the usefulness of ETCO2 monitoring to detect respiratory depression during PSA in the Emergency Department. Investigators compared ETCO2 measurements with the Observer’s Assessment of Alertness/Sedation (OAA/S) scale and the development of respiratory depression and found no significant correlation between ETCO2 and the OAA/S scale. Respiratory depression was defined as ETCO2 $\leq 50$ mmHg, oxygen saturation (SpO2) $\geq 90\%$, or an absence of capnography waveform. Thirty-three patients (44.6%) experienced respiratory depression, all of which were detected by ETCO2 changes, regardless of pulse oximetry readings. Five of 47 patients (10.6%) receiving supplemental oxygen experienced hypoxia compared with 6 of 27 patients (22.2%) breathing room air.

Vargo et al (2002) [4]: This study challenged guidelines from the ASA that recommend capnography as the preferred method for continuously monitoring ventilation in PSA. In patients undergoing therapeutic upper endoscopy, the study goals were to determine the 1) frequency of ventilation events, 2) sensitivity of observation and pulse oximetry in the detection of ventilation events, and 3) whether capnography provides an improvement over accepted monitoring techniques. Forty-nine patients undergoing therapeutic upper endoscopy were monitored with standard methods including pulse oximetry, automated blood pressure measurement, and visual assessment. Graphic assessment of respiratory activity with sidestream capnography also was performed in all patients. Endoscopy personnel were blinded to capnography data, and episodes of apnea or disordered respiration detected by capnography were documented and compared with the occurrence of hypoxemia, hypercapnia, hypotension, and the recognition of abnormal respiratory activity by endoscopy personnel. The authors reported that “comparison of simultaneous respiratory rate measurements obtained by capnography and by auscultation

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### Table 2  Summary of trials and individual diagnostic odds ratios

<table>
<thead>
<tr>
<th>Trial Year</th>
<th>First author</th>
<th>N</th>
<th>Events detected Caex (TP)</th>
<th>Events not detected Caex (FP)</th>
<th>Events not detected Coex (FN)</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>SELog Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2006</td>
<td>Burton</td>
<td>60</td>
<td>17</td>
<td>21</td>
<td>3</td>
<td>19</td>
<td>5.13</td>
<td>1.30-20.29</td>
</tr>
<tr>
<td>2 2008</td>
<td>Deitch</td>
<td>110</td>
<td>10</td>
<td>26</td>
<td>14</td>
<td>50</td>
<td>1.37</td>
<td>0.54-3.52</td>
</tr>
<tr>
<td>3 2004</td>
<td>Soto</td>
<td>39</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>29</td>
<td>330.00</td>
<td>18.96-5743.07</td>
</tr>
<tr>
<td>4 2002</td>
<td>Vargo</td>
<td>49</td>
<td>29</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>638.00</td>
<td>37.77-10775.69</td>
</tr>
<tr>
<td>5 2002</td>
<td>Miner</td>
<td>74</td>
<td>9</td>
<td>24</td>
<td>2</td>
<td>39</td>
<td>7.31</td>
<td>1.46-36.74</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>332</td>
<td>75</td>
<td>71</td>
<td>19</td>
<td>157</td>
<td>7.93</td>
<td>4.55-13.84</td>
</tr>
</tbody>
</table>

Caex (TP) cases exposed: true positives, Coex (FP) controls exposed: false positives, Canex(FN) cases non-exposed: false negatives, Conex(TN) controls non-exposed: true negatives.

* Weight calculated by DerSimonian and Laird Method (wi = 1/se$log^2$).
† For analytic purposes, all values in rows containing zero were modified by adding a value of 1.
‡ Pooled crude odds ratio.

### Table 3  Test statistics

<table>
<thead>
<tr>
<th></th>
<th>Fixed-effects</th>
<th>Random effects</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M-H method</td>
<td>Peto method</td>
</tr>
<tr>
<td>Pooled weighted OR and 95% CI</td>
<td>6.5</td>
<td>7.7</td>
<td>17.6</td>
</tr>
<tr>
<td>Association *</td>
<td>(3.8-11.1)</td>
<td>(4.5-13.7)</td>
<td>(2.5-122.1)</td>
</tr>
<tr>
<td>d.f.</td>
<td>59.7</td>
<td>59.6</td>
<td>8.38</td>
</tr>
<tr>
<td>$P$-value</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td>0.004</td>
</tr>
<tr>
<td>Heterogeneity</td>
<td>30.4</td>
<td>36.4</td>
<td>4</td>
</tr>
<tr>
<td>d.f.</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>$P$-value</td>
<td>&lt; 0.0001</td>
<td>&lt; 0.0001</td>
<td></td>
</tr>
<tr>
<td>Cochran Q heterogeneity test *</td>
<td>27.0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>d.f.</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$P$-value</td>
<td>0.0001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterogeneity statistic †</td>
<td>85.2</td>
<td>(67.1-93.3)</td>
<td></td>
</tr>
<tr>
<td>95% CI</td>
<td>Between train variance ‡</td>
<td>3.9</td>
<td></td>
</tr>
</tbody>
</table>

* Chi square test.
† I squared test.
‡ Tau squared test.
with a pretracheal stethoscope verified that capnography was an excellent indicator of respiratory rate when compared with the reference standard (auscultation) \( r = 0.967, P < 0.001 \). Fifty-four episodes of apnea or abnormal respiration occurred in 28 patients (mean duration, 70.8 seconds) and only 50% of apnea or abnormal respiration episodes were detected by pulse oximetry (SpO\(_2\) < 90%). None of these episodes was detected by visual assessment (\( P < 0.001 \)).

Soto et al (2004) [9]: This study started with the premise that apnea and airway obstruction are common during monitored anesthesia care. The investigators were particularly interested in early detection and sought to measure the efficacy of capnography as an indicator of apnea during monitored anesthesia care at different oxygen flow rates compared with thoracic impedance. Anesthesia care providers were blinded to capnography and thoracic impedance monitoring. Ten (26%) of the 39 patients studied developed 20 seconds of apnea; none was detected by the anesthesia provider, but all were detected by capnography and impedance monitoring (no difference in detection rates between the two methods). Higher oxygen flow rates decreased the amplitude of the capnograph but did not interfere with apnea detection.

Burton et al (2006) [2]: The primary goal of this study was to determine if ETCO\(_2\) monitoring could detect acute respiratory events before detection by other current monitoring methods in patients undergoing procedural sedation in the emergency department. Abnormal ETCO\(_2\) events were documented in 60% of the 60 patients enrolled (31 with low values, 4 with high values, and one with both high and low values). Of these patients, 20 developed acute respiratory events requiring some type of intervention and 85% showed ETCO\(_2\) findings indicative of hypoventilation or apnea during PSA. Abnormal ETCO\(_2\) findings were documented before changes in SpO\(_2\) or clinically observed hypoventilation in 14 (70%) of these patients with acute respiratory events.

Deitch et al (2008) [10]: This study had two stated goals, the first to determine whether supplemental oxygen reduced the incidence of hypoxia (compared with breathing room air) in adult patients receiving propofol for emergency department procedural sedation. The second was to determine the degree to which physicians who were blinded to capnographic data could recognize respiratory depression during procedural sedation. Fifty-six patients received supplemental oxygen and 54 received room air. Of the 25 patients who developed hypoxia, physicians could identify respiratory depression in 23 patients, but identified only one of the 27 patients who met ETCO\(_2\) criteria for respiratory depression and who did not have hypoxia.

### 3.2. Results of the meta-analysis

Table 2 summarizes the abstracted raw data on the respiratory complications and whether these adverse events were detected by capnography. The crude pooled OR between adverse respiratory events and their detection by capnography was 7.93, 95% CI (4.55-13.84). Table 2 presents weighted ORs showing the association between adverse respiratory events and their detection by capnography in each study, obtained using these three methods: fixed-effects models (Peto and Mantel-Haenszel methods) and random-effects model (Dersimonian-Laird method).

The range of individual ORs is high (1.37-638.00) (Table 2), which indicates a high level of variability between the studies. Logarithmic transformation of weighted ORs was plotted as a histogram and showed that the distribution was close to normal and slightly skewed to the right, which was probably explained by a small sample size (5 studies). High variability between studies also was supported by findings of heterogeneity analysis, as summarized in Table 3. These findings from the fixed-effects analyses show significant heterogeneity between studies. The random-effects model also showed a substantial amount of variability between the studies. Heterogeneity before taking tau-square into consideration (Cochran Q heterogeneity test) was: \( \text{Chi}^2 = 27.0, \text{d.f.} = 4, P = 0.0001. \) The heterogeneity statistic \( I^2(\%) = 85.2 \) (interpreted as between moderate to high heterogeneity, 95% CI (67.1-93.3)), and the tau-squared test (between-trials variance) = 3.9. All statistical estimates were obtained using SPSS Version 15 macro for fixed-effects and random-effects meta-analysis models (SPSS, Inc.).

Pooled weighted ORs of adverse respiratory events and their detection by capnography are shown in Table 3: 6.5, 95% (3.8-11.1), 7.7 (4.5-13.7), and 17.6 (2.5-122.1), for the Mantel-Haenszel, Peto, and Dersimonian-Laird methods, respectively. All of these associations are statistically significant at the 95% confidence level (Table 3).

Since heterogeneity between the studies is high, the results of the random-effects model are the most appropriate statistical inference in this meta-analysis. Overall adverse respiratory events in patients undergoing procedural sedation were 17.6 times as likely to be associated with abnormal ETCO\(_2\) findings and to be detected correctly if monitored by capnography than if they were not monitored by capnography.

### 4. Discussion

The pooled findings of this secondary analysis show that the addition of capnography to patient monitoring during procedural sedation significantly increased the detection of adverse respiratory events. If there is an easy, safe, and inexpensive way to enhance their detection, it is logical to take advantage of that method. This would be especially helpful in situations where the procedure becomes unexpectedly complex and demanding of attention, if the patient is covered in a way that makes assessment difficult, or if only limited staff are available to care for the patient.

Pulse oximetry is commonly used as the sole method for routine monitoring of patient oxygenation status. Because of the availability and ease of use of pulse oximetry, many
clinicians attempt to use it for off-label monitoring of ventilatory status. Data in the literature do not support substituting oximetry for capnography when monitoring respiratory depression, and some investigators have concluded that it would be dangerous to do so \cite{4,10}. Pulse oximetry is even less sensitive to adverse changes related to ventilation when supplemental oxygen is used, which is commonplace during procedural sedation \cite{1,2}.

\section*{4.1. Important new aspects of the study}

Many groups have published recommendations for the PSA environment that are directed primarily toward non-anesthesiologists \cite{11-13}. The recommendations for monitoring tend to be nonspecific, encouraging only some means of continuous monitoring for oxygenation and ventilation to detect the primary causes of adverse events associated with PSA (respiratory depression and airway obstruction) \cite{11}. Many practitioners use pulse oximetry as the sole monitor for both oxygenation and ventilation. Reasons include ease of use and interpretation, availability, cost of equipment, and lack of data showing the use of alternate monitoring modalities \cite{14}. Although anesthesia providers are more likely to use capnography to monitor ventilatory status in PSA, a majority of practitioners who provide PSA do not use capnography in non-operating room settings, including GI suites, cardiac suites, and emergency departments. Sedation guidelines published by various professional organizations tend to recommend a continuous qualitative assessment of ventilation (e.g., visual inspection, auscultation) but rarely specify capnography, most likely due to a paucity of outcomes data and the logistics of implementing such a recommendation. The findings reported here along with other literature suggest that an evidence-based recommendation may be made. This study highlights the improved detection using pulse oximetry in conjunction with capnography in PSA and advocates the use of capnography as an essential element in non-operating room environments.

\section*{4.2. Limitations of the study}

Analysis of statistics for respiratory complications related to PSA is fraught with difficulties. Differing definitions, different study designs and sampling methods, incomplete reporting of total procedures, and preexisting patient status are a few reasons that render traditional meta-analysis comparisons difficult. In spite of these limitations, some published data do lend themselves to pooling and statistical summary.

As is often the case with secondary analysis, there was a wide variation in research design among the publications reviewed, which limited the number that could be included. The small final number and statistical heterogeneity of effect sizes between the studies restrict the conclusions that may be drawn and the degree to which they may be extrapolated to the clinical setting. Despite these limitations, this analysis suggests that ETCO\textsubscript{2} monitoring is an important addition to oximetry in detecting respiratory depression.

\section*{4.3. Conclusions}

Capnography is an important addition to pulse oximetry in detecting respiratory depression during procedural sedation. There is no support for substituting pulse oximetry for traditional monitoring of respiratory depression such as capnography, and doing so could be dangerous, especially when supplemental oxygen is used.

\section*{Acknowledgment}

The authors thank Ms. Lee Vucovich, MS, MLS, for her assistance with searching the electronic databases used in this study.

\section*{Appendix A. Detailed search strategy}

\textbf{PubMed search strategy}


\begin{enumerate}
  \item "capnography" [MeSH Terms] OR "capnography" [All Fields]
  \item Capnograph* OR capnomet*
  \item ((("Carbon dioxide/analysis" [MeSH]) OR (end-tidal CO\textsubscript{2})) AND ("Monitoring, Physiologic/methods" [MeSH]))
  \item "procedural sedation" [All Fields] OR "conscious sedation" [MeSH Terms] OR "conscious sedation" [All Fields]
  \item "analgesia, patient-controlled" [MeSH Terms] OR "patient-controlled analgesia" [All Fields] OR "analgesia, patient controlled" [All Fields]
  \item "deep sedation" [MeSH Terms] OR "deep sedation" [All Fields]
  \item "ambulatory surgical procedures" [MeSH Terms] OR "ambulatory surgical procedures" [All Fields]
  \item "biopsy" [MeSH Terms] OR "biopsy" [All Fields]
  \item "refractive surgical procedures" [MeSH Terms] OR "refractive surgical procedures" [All Fields]
  \item "tracheostomy" [MeSH Terms] OR "tracheostomy" [All Fields]
  \item "tracheostomy" [MeSH Terms] OR "tracheostomy" [All Fields]
  \item "paracentesis" [MeSH Terms] OR "paracentesis" [All Fields]
  \item "surgical procedures, minimally invasive" [MeSH Terms] OR "minimally invasive surgical procedures" [All Fields]
  \item "electroconvulsive therapy" [MeSH Terms] OR "electroconvulsive therapy" [All Fields]
  \item "debridement" [MeSH Terms] OR "debridement" [All Fields]
\end{enumerate}
Capnography for procedural sedation

16. "ablation techniques" [MeSH Terms] OR "ablation techniques" [All Fields]
17. "abortion, induced" [MeSH Terms] OR "induced abortion" [All Fields] OR "induced abortions" [All Fields]
18. 1 OR 2 OR 3
19. 4 OR 5 OR 6
20. 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 1721
21. 19 OR 20
22. 18 AND 21 (150 citations)
23. 22 AND "clinical trial" [Filter] (38 citations)

CINAHL search strategy
CINAHL was searched using the EBSCOhost interface on 7/7/2009 for the time period 1995-2009. Limit to English language.
1. MH capnography or TX capnograph* or TX capnomet or TX CO2 monit* or TX carbon dioxide monit* or TX end-tidal CO2
2. "procedural sedation"
3. ("conscious sedation") or (MH "Conscious Sedation")
4. ("patient controlled analgesia") or (MH "Patient-Controlled Analgesia")
5. "deep sedation"
6. ("biopsies") or (MH "Biopsy+")
7. (MH "Paracentesis+")
8. ("electric counter shock") or (MH "Electroconvulsive Therapy")
9. ("Debridement") or (MH "Debridement")
10. ("ablation") or (MH "Catheter Ablation")
11. ("induced abortions") or (MH "Abortion, Induced")
12. ("ambulatory surger") or (MH "Ambulatory Surgery")
13. "refractive surgical procedure"
14. ("tracheostom") or (MH "Tracheostomy")
15. "tracheotom"
16. ("minimally invasive surger") or (MH "Minimally Invasive Procedures")
17. ("endoscopy") or (MH "Endoscopy+")
18. S2 or S3 or S4 or S5
19. S6 or S7 or S8 or S9 or S10 or S11 or S12 or S13 or S14 or S15 or S16 or S17
20. S18 or S19
21. S20 and S1 (126 citations)
22. Limit Research article (48 citations)

Cochrane search strategy
The Cochrane Library was searched on 7/12/2009 using the Wiley InterScience Interface for the time period 1995-2009.
1. Capnograph* or capnom*
2. End NEXT tidal CO NEAR/4 2
3. "Conscious sedation"
4. "Procedural sedation"
5. "Deep sedation"
6. (Patient NEXT controlled analgesia)
7. "ambulatory surgical procedures"
8. Biopsy
9. “Refractive surgical procedure”
10. Trachostomy
11. Trachometry
12. Paracentesis
13. Endoscopy
14. “Surgical procedures, minimally invasive”
15. Electroconvulsive therapy
16. Electric countershock
17. Debridement OR “ablation techniques”
18. Induced abortions OR “abortions, induced”
19. #1 OR #2
20. #3 OR #4 OR #5 OR #6
21. #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #182
22. #20 OR #21
23. #19 AND #22 (27 citations)

Searches using Science Citation Index Expanded in the ISI Web of Science (Thomson Reuters, New York, NY, USA) interface and Google Scholar were carried out 7/22/2009-7/24/2009 to identify papers citing the following articles:
References


